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EXTERNAL LIQUID LOOP HEAT EXCHANGER FOR AN ELECTRONIC SYSTEM

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BACKGROUND OF THE INVENTION

[0001] Electronic systems and equipment such as computer systems, network interfaces, storage systems, and telecommunications equipment are commonly enclosed within a chassis, cabinet or housing for support, physical security, and efficient usage of space. Electronic equipment contained within the enclosure generates a significant amount of heat. Thermal damage may occur to the electronic equipment unless the heat is removed.

[0002] Compact electronic systems and devices, for example compact computer servers with a rack-mount 1U form factor, typically have very little space available for implementing a cooling capability. Conventional air-cooled heat sinks generally must be directly connected to the heat source. The footprint of the heat sink cannot be much larger than the heat source given the intrinsic heat spreading resistance of an aluminum or copper heat sink. Given the restriction on heat sink height dictated by the form factor and the practical limits on heat sink footprint, cooling capabilities are highly restricted.

SUMMARY

[0003] In accordance with an embodiment of a cooling apparatus for usage in an electronic system, a liquid loop heat exchanger body is configured for attachment to an exterior surface of an electronic system chassis.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] Embodiments of the invention relating to both structure and method of operation, may best be understood by referring to the following description and accompanying drawings.

[0005] **FIGURE 1** is a perspective pictorial diagram showing a cooling apparatus for usage in an electronic system.

[0006] **FIGUREs 2A**, **2B**, and **2C** are schematic pictorial diagrams illustrating various embodiments of suitable heat exchanger bodies.

[0007] **FIGURE 3** is a frontal pictorial view illustrating an embodiment of a heat exchanger with an ornamental shape.

[0008] **FIGUREs 4A** and **4B** are perspective pictorial views showing embodiments of heat exchangers arranged to complement various chassis structures such as indicator lights and access doors.

[0009] **FIGUREs 5A** and **5B** are perspective pictorial views showing embodiments of hinged heat exchangers that enable movement of the heat exchangers away from the chassis for system access.

[0010] **FIGURE 7** is a perspective pictorial diagram that illustrates an embodiment of a liquid loop cooling system and an electronic system.

DETAILED DESCRIPTION

[0011] Referring to **FIGURE 1**, a perspective pictorial diagram depicts a cooling apparatus **100** for usage in an electronic system **102** comprises a liquid loop heat exchanger body **104** is configured for attachment to an exterior surface **106** of an electronic system chassis **108**.

[0012] The cooling apparatus **100** may further include a tube **110** capable of enclosing a cooling fluid. The tube **110** extends in a loop that passes interiorly though the heat exchanger body **104** external to the electronic system chassis **108** and also passes into the chassis **108** to cooling plates **112** coupled to electronic components interior to the electronic system chassis **108**. The cooling apparatus **100** may also have a pump **114** coupled into the tube **110** that is capable of generating a pressure head suitable to drive the cooling fluid interior to the tube **110** through the loop interior and exterior of the chassis **108**.

[0013] Electronic system architectures such as server architectures with a compact form factor may include the liquid loop cooling apparatus **100** to accommodate increasing power and power density levels of components including microprocessors and associated electronics. The liquid loop cooling apparatus **100** uses the pump **114** to drive the cooling fluid through high pressure-drop channels of the cold plates **112** attached to processors and other high-power components. The pump **114** also drives the cooling fluid along a potentially long and narrow-diameter tube **110** that completes the loop between the cold plates **112**, the heat exchanger **104**, and the pump **114**. Forced-air convection at the heat exchanger **104** removes heat from the loop.

[0014] The heat exchanger **104** is located exterior to the electronic system chassis **108**. In some embodiments, the heat exchanger **104** is located on a frontal surface of the chassis **108**, for example either behind a traditional computer bezel or as a replacement to the bezel. In the illustrative embodiment, the heat exchanger body **104** is adapted to mount on the frontal exterior surface of the chassis **108**, a useful configuration for locating the liquid loop heat exchanger on a rack-mounted chassis. In other embodiments, the heat exchanger can be positioned on other external surfaces of the chassis or positioned at a distance from the chassis. Positioning of the heat exchanger body **104** exterior to a chassis, for example for usage with a compact form-factor computer server chassis, enables the heat exchanger to have physical dimensions that are larger than can be contained within the chassis.

[0015] The electronic system **102** may be any type of device or combination of devices that includes possibly heat-generating components within a chassis **108**, housing,

or other suitable container. Typical types of electronic systems **102** include computer systems, servers, host systems, storage devices such as one or more of various types of disk storage systems including compact disks (CDs), Digital Versatile Disks (DVDs), hard disks and the like. Other types of electronic system **102** include communication systems or devices, routers, blades, application control devices, and devices for many other applications.

[0016] Commonly the chassis **110** is a sheet metal chassis, although in some embodiments, the chassis may be constructed from other materials such as plastics and the like.

[0017] Referring to **FIGUREs 2A**, **2B**, and **2C**, three schematic pictorial diagrams illustrate various embodiments of suitable heat exchanger bodies **200**, **210**, and **220**, respectively. The illustrative heat exchanger bodies include at least one tube segment **202** that encloses a cooling fluid for circulation through the tubing loop. The tube segment or segments **202** are positioned interior to the heat exchanger body **200**, **210**, and **220**. The heat exchanger bodies **200**, **210**, and **220** also have a plurality of fins **204** that can be configured in a stack of closely-spaced plates attached to the tube segments **202**.

[0018] Referring to **FIGURE 2A**, a perspective pictorial diagram illustrates an embodiment of a single-pass heat exchanger **210** that includes a plurality of fins **204** attached to the tube **202** containing cooling fluid. As shown in **FIGURE 2B**, the tube **202** may pass through a fin bank **204** multiple times and in various orientations to attain improved or optimized cooling performance. **FIGURE 2C** is a frontal pictorial view that illustrates an embodiment of a single-pass heat exchanger **220** including multiple fins **204** attached to a tube **202**.

[0019] Referring to **FIGURE 3**, a frontal pictorial view illustrates an embodiment of a heat exchanger **300** with an ornamental shape. The heat exchanger **300** is positioned exterior to an electronic system chassis and includes a tube segment **302** that can enclose a cooling fluid. The tube segment **302** is positioned interior to the heat exchanger body **300**. The heat exchanger **300** further includes a plurality of fins **304** configured in an

ornamental arrangement and attached to the tube segment **302** at the frontal surface of the electronic system chassis.

[0020] Positioning the heat exchanger **300** on the front of a system chassis may enable elimination of a bezel, often constructed from plastic, which is traditionally mounted to electronic systems, such as computer systems. The fins **304** may be arranged to attain an attractive appearance to attain the ornamental purpose of the bezel, while adding system cooling functionality. In various embodiments, ornamental structures can be formed by arranging the fins **304** horizontally, vertically, or at an angle, or by including fins with multiple various orientations. The fins **304** may be configured with varying pitch, height, width, color, texture, and the like.

[0021] Referring to **FIGUREs 4A** and **4B**, two perspective pictorial views show embodiments of heat exchangers arranged to complement various chassis structures such as indicator lights and access doors. Fins **402** of a heat exchanger body **400** can be variable in width and height along a surface of the electronic system chassis **404** to accommodate indicator lights **406**, access to removable input/output devices **408**, and/or labeling. The fins **402** may be interrupted in various places along the length of the heat exchanger **400** also to accommodate input/output access doors, indicator lights, ornamental and other labeling, displays, switches, buttons, and the like. **FIGURE 4A** shows an example of a heat exchanger **400** with vertically-aligned fins **402**. **FIGURE 4B** shows a heat exchanger **410** with horizontally-aligned fins **402**.

[0022] Referring to **FIGUREs 5A** and **5B**, two perspective pictorial views show embodiments of hinged heat exchangers **500** and **510**, respectively, which enable movement of the heat exchangers away from the chassis for system access. The heat exchangers **500** and **510** include an inlet tube **502** and an outlet tube **504** coupled to the heat exchanger body and hinges **506** coupled to at least one of the inlet tube **502** and outlet tube **504** enabling the heat exchanger body to be rotated away from the electronic system chassis for repairs, insertion and removal of input/output media, and other user and/or service access.

[0023] Referring to **FIGUREs 6A, 6B**, and **6C**, several schematic pictorial diagrams illustrate an embodiment of a suitable hinge for usage in a heat exchanger body. **FIGURE 6A** is a perspective pictorial diagram showing separated parts of an embodiment of a cylindrical tubing hinge **600** that extends around and couples two segments **602, 604** of a rigid or semi-rigid tubing and enables radial motion of one segment relative to the other. The tubing hinge **600** includes the first and second tubing segments **602, 604** that can be arranged to share a common longitudinal axis **606**. The tubing segments **602, 604** terminate in respective first and second tube ends **612, 614**. A raised lip **622** on the first tube end **612** extends radially outward relative to the longitudinal axis **606**. A raised groove **624** on the second tube end **614** extends radially outward and returns radially inward relative to the longitudinal axis **606** in a longitudinal section of the second tubing segment **604**. An O-ring **610** encircles a longitudinal segment of the first tube **602** adjacent and restrained by the raised lip **622** and contained within the raised groove **624** of the second tube end **614**.

[0024] **FIGURE 6B** is a perspective pictorial diagram showing the combined hinge **600**. The first tube end **612** is inserted into the second tube end **614** so that the first tube end raised lip **622** is confined within the second tube end raised groove **624**. **FIGURE 6C** is a side sectional view of the hinge embodiment **600**.

[0025] Referring to **FIGURE 7**, a perspective pictorial diagram illustrates an embodiment of a liquid loop cooling system **700** that comprises a tubing **702** forming a loop extending through an electronic system chassis **704** interior to selectively apply cooling to interior system components **706**. The tubing **702** exits the chassis **704** to form an exterior tubing segment **708** exterior to the chassis **704**. The liquid loop cooling system **700** further includes a liquid loop heat exchanger **710** exterior to the chassis **704** that is coupled to the exterior tubing segment **708**.

[0026] In some embodiments, the liquid loop cooling system **700** may further include a pump **712** coupled to the tubing **702** that is capable of generating a pressure head suitable to drive a cooling fluid interior to the tubing **702** through the loop interior and exterior to the chassis **704**. Some embodiments may omit the pump **712**. For example the fluid motion may be gravity-aided or a wick structure may be used in the tubing to

drive the fluid. The liquid loop cooling system **700** also may include one or more cold plates **714** coupled to the tubing **702**, typically positioned near heat-generating components **706** to supply local cooling.

[0027] The pumped liquid loop enables the heat exchanger **710** to be located relatively far from the cold plate **714**. The pump **712** used for the liquid loop cooling system **700** generates a considerable pressure head, enabling the tubing **702** of the loop to be quite long so that the heat exchanger **710** can be located outside of the chassis **704**. By removing the heat exchanger **710** from the chassis **704**, components **706** interior to the chassis **704** can be packaged more efficiently due to the added capacity made available.

[0028] Also referring to **FIGURE 7**, the diagram also depicts an electronic system **716** comprises the chassis **704** including airflow inlet and outlet vents **718**, and fans **720** capable of circulating air from the inlet vents to the outlet vents **718**. The electronic system **716** further includes a plurality of components **706** and devices such as input/output devices **722** mounted within the chassis **704** and forming local heat sources.

[0029] The electronic system **716** further includes the tubing **702** forming a loop that extends through the chassis **704** interior to selectively apply cooling to the components **706** and exits the chassis to the exterior tubing segment **708** exterior to the chassis **704**. The electronic system **716** also includes the liquid loop heat exchanger **710** positioned exterior to the chassis **704** that is coupled to the exterior tubing segment **708**.

[0030] In a compact electronic system **716**, for example a compact server or computer system, cooling air is driven across the heat exchanger **710** using tube-axial or blower fans **720** in close proximity to the heat exchanger fins. Redundant fans **720** are typically used for electronic systems **716**. In some applications, the fans **720** can be located inside the computer chassis **704**, not necessarily in close proximity to the heat exchanger **710**. In some embodiments, an external heat exchanger **710** located at the front of the chassis **704** may use system fans **720** inside the chassis **704** for cooling and/or additional fans added directly to the heat exchanger **710**. Furthermore, an external heat exchanger **710** located in the front of the chassis **704** may receive supplemental or primary cooling air driven by fans integrated into the electronics rack. The capability of using the external

heat exchanger **710** with various fan arrangements enables a high degree of flexibility in configuring a cooling capability. For example, rack-level fans can have small sizes or large sizes, as desired, to appropriately cool a rack of systems with various capacities.

[0031] For electronic systems **716** that locate the heat exchanger **710** at the front of the chassis **704**, the heat exchanger **710** receives air at ambient temperature with no pre-heating that occurs due to heat generation inside the chassis, attaining a most efficient thermal performance. The heat exchanger **710** located on the front of the chassis **704** also receives additional cooling via natural convention and radiation to the environment, reducing forced-air cooling constraints.

[0032] In some embodiments the heat exchanger **710** can be adapted for mounting on an exterior surface of a compact form factor computer server chassis and be made with physical dimensions that are larger than can be contained within the chassis. Removing the heat exchanger **710** outside the chassis **704** enables the heat exchanger to be made as large as the external dimensions of the chassis **704**. Otherwise, for a heat exchanger constrained to be located inside the chassis, a size limitation is imposed by the smaller physical dimensions interior to the chassis. Less efficient cooling results due to the smaller size of the heat exchanger, difficulty of installation, and proximity or conflict with other system components.

[0033] Locating the heat exchanger outside the chassis leaves more room available inside the chassis for components or to enable reduction in system size, and instead consumes exterior space that is otherwise unoccupied or occupied by a generally ornamental bezel. Furthermore, the heat exchanger can accommodate ornamental industrial design by configuration of the fins.

[0034] The liquid loop cooling system **700** can be configured by arranging the tubing **702** in a loop extending through the electronic system interior to the chassis **704** and outside the chassis **704**. The liquid loop heat exchanger **710** is mounted on the exterior of the chassis **704** and the tubing loop exterior to the chassis is connected to the liquid loop heat exchanger **710**.

[0035] Routing of the loop can be determined by determining the heat distribution within the electronic system chassis **704** that results from the heat-generating contribution of the plurality of components **706**. The tubing loop can be arranged to extend through the chassis interior to selectively apply cooling to heat-generating components. The tubing **702** inside the chassis **704** can be connected to one or more cold plates **714** selectively positioned to cool the heat-generating components.

[0036] One or more fans **720** can be positioned to drive air through the liquid loop heat exchanger **710**. The fans can be positioned interior to the chassis, exterior to the chassis, or a combination of interior and exterior to the chassis.

[0037] The tubing **702** is connected to a pump **712** to drive the cooling fluid through the loop.

[0038] While the present disclosure describes various embodiments, these embodiments are to be understood as illustrative and do not limit the claim scope. Many variations, modifications, additions and improvements of the described embodiments are possible. For example, those having ordinary skill in the art will readily implement the steps necessary to provide the structures and methods disclosed herein, and will understand that the process parameters, materials, and dimensions are given by way of example only. The parameters, materials, and dimensions can be varied to achieve the desired structure as well as modifications, which are within the scope of the claims. Variations and modifications of the embodiments disclosed herein may also be made while remaining within the scope of the following claims. For example, although particular geometries of the heat exchanger are shown, other arrangements are possible including multiple-pass arrangements in which additional tube segments are added. Also, particular electronic system embodiments are illustrated, for example a computer server. In other embodiments, the external heat exchanger can be employed in other types of electronic systems such as communication systems, storage systems, entertainment systems, and the like.